JC10 Rec'd PCT/PTO 19 DEC 2001

FORM PTO 1390
(REV 5-93)

US DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. §371

ATTORNEY DOCKET NUMBER
2001_1855A

U.S. APPLICATION NO.
(if known, see 37 CFR 1.5)
NEW 10/018361

International Application No.	International Filing Date	Priority Date Claimed
PCT/NO00/00215	June 22, 2000	June 23, 1999

Title of Invention
DEEP WATER TLP TETHER SYSTEM

Applicant(s) For DO/EO/US
Graham PERRET, Henrik HANNUS and Kjetil ECKHOFF

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. §371.

2. [] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. §371.

3. [X] This express request to begin national examination procedures (35 U.S.C. §371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. §371(b) and PCT Articles 22 and 39(1).

4. [X] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. [X] A copy of the International Application as filed (35 U.S.C. §371(c)(2))
   a. [] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [X] has been transmitted by the International Bureau. **ATTACHMENT A**
   c. [] is not required, as the application was filed in the United States Receiving Office (RO/US)

6. [X] A copy of the International Application (35 U.S.C. §371(c)(2)). **ATTACHMENT B**

7. [] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. §371(c)(3)).
   a. [] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [] have been transmitted by the International Bureau.
   c. [] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [] have not been made and will not be made.

8. [] A translation of the amendments to the claims under PCT Article 19.

9. [] An oath or declaration of the inventor(s) (35 U.S.C. §371(c)(4)).

10. [] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. §371(c)(5)).

Items 11. to 14. below concern other document(s) or information included:

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98. **ATTACHMENT D**

12. [] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. [X] A FIRST preliminary amendment. **ATTACHMENT E**

    [] A SECOND or SUBSEQUENT preliminary amendment.

14. [X] Other items or information:

    Unexecuted Declaration and Power of Attorney with cover letter - **ATTACHMENT C**

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U.S. APPLICATION NO. 10/018361 NEW	INTERNATIONAL APPLICATION NO. PCT/NO00/00215	ATTORNEY'S DOCKET NO. 2001_1855A	
15. [X] The following fees are submitted		CALCULATIONS	PTO USE ONLY

BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5)):

Neither international preliminary examination fee nor international search fee paid to USPTO and International Search Report not prepared by the EPO or JPO $1040.00

International Search Report has been prepared by the EPO or JPO .... $ 890.00

International preliminary examination fee not paid to USPTO but international search paid to USPTO .... $ 740.00

International preliminary examination fee paid to USPTO but claims did not satisfy provisions of PCT Article 33(1)-(4) .... $ 690.00

International preliminary examination fee paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) .... $ 100.00

Claims	Number Filed	Number Extra	Rate	Calculations	PTO Use Only
ENTER APPROPRIATE BASIC FEE AMOUNT =				$1,040.00	
Surcharge of $130.00 for furnishing the oath or declaration later than [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$	
Total Claims	10 -20 =	--0--	X $18.00	$	
Independent Claims	3 - 3 =	--0--	X $84.00	$	
Multiple dependent claim(s) (if applicable)			+ $280.00	$	
TOTAL OF ABOVE CALCULATIONS =				$1,040.00	
[] Small Entity Status is hereby asserted. Above fees are reduced by 1/2.				$	
SUBTOTAL =				$1,040.00	
Processing fee of $130.00 for furnishing the English translation later than [] 20 [] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$1,040.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40 per property +				$	
TOTAL FEES ENCLOSED =				$1,040.00	
				Amount to be refunded	$
				Amount to be charged	$

a. [X] A check in the amount of $1,040.00 to cover the above fees is enclosed. A duplicate copy of this form is enclosed.

b. [] Please charge my Deposit Account No. 23-0975 in the amount of $________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 23-0975.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

19. CORRESPONDENCE ADDRESS

000513

PATENT TRADEMARK OFFICE

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December 19, 2001

[CHECK NO. 48047

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10/018361

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of	:	
Graham PERRET et al.	:	**Attn: BOX PCT**
Serial No. NEW	:	**Docket No. 2001_1855A**
Filed December 19, 2001	:	THE COMMISSIONER IS AUTHORIZED TO CHARGE ANY DEFICIENCY IN THE FEE FOR THIS PAPER TO DEPOSIT ACCOUNT NO. 23-0975.
DEEP WATER TLP TETHER SYSTEM **[Corresponding to PCT/NO00/00215 Filed June 22, 2000]**		

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents,
Washington, DC 20231

Sir:

Prior to initial examination of the above-identified application, kindly amend the application as follows:

IN THE SPECIFICATION:

Kindly replace the original specification and abstract as filed in the International Stage with the enclosed substitute specification and abstract.

IN THE CLAIMS:

Kindly cancel claims 1-12 without prejudice or disclaimer recited thereof.

Kindly add the following new claims:

13.(NEW) Tether system for tension leg platforms (4), with tethers (6) having upper and lower pipe sections (1, 2), characterized by the tethers (6) having a stepped reduction of the diameter towards the seabed such that the upper section(s) (1) have

positive buoyancy, and such that the upper section(s) (1) compensate for the weight in water of the lower section(s) (2) and such that the tethers (6) has an increasing pressure resistance as the depth towards the sea-bed increases.

14.(NEW) Tether system for tension leg platforms, characterized by tethers (6) having pipes of different diameter, with a substantially continuous reduction, and an increased pressure resistance towards the sea-bed.

15.(NEW) Tether system for tension leg platforms (4) in accordance with claim 13, characterized by the tether system having a weight in water close to neutral.

16.(NEW) Tether system (6) for tension leg platforms (4) in accordance with claim 13, characterized by having decreasing buoyancy towards the seabed.

17.(NEW) Tether system for tension leg platforms (4) according to claim 13, characterized by tethers having pipes with at least two stepped reductions of the diameter towards the seabed.

18.(NEW) Tether system for tension leg platforms (4) according to claim 13, characterized by tethers having pipes with at least two stepped increases of the wall thickness towards the seabed.

19.(NEW) Tether system for tension leg platforms (4) in accordance with claim 13, characterized by having upper sections (1) with reduced wall thickness such that the total cross sectional area of the pipe wall is maintained approximately constant over the height.

20.(NEW) Tether system for tension leg platforms (4) in accordance with claim 13, characterized by having sections made of steel.

21.(NEW) Tether system for tension leg platforms (4) in accordance with claim 13, characterized by having sections made of composite materials.

22.(NEW) Use of tethers (6) having upper and lower pipe sections (1, 2), and a stepped reduction of the diameter towards the seabed such that the upper section(s) (1) have positive buoyancy, and such that the upper section(s) (1) compensate for the weight in water of the lower section(s) (2) and such that the tethers (6) has an increasing pressure resistance as the depth towards the sea-bed increase at deep-sea installations.

23.(NEW) Tether system for tension leg platforms (4) in accordance with claim 15, characterized by the tether system having a weight in water close to neutral.

24.(NEW) Tether system (6) for tension leg platforms (4) in accordance with claim 15, characterized by having decreasing buoyancy towards the seabed.

25.(NEW) Tether system for tension leg platforms (4) in accordance with claim 15, characterized by having upper sections (1) with reduced wall thickness such that the total cross sectional area of the pipe wall is maintained approximately constant over the height.

26.(NEW) Tether system for tension leg platforms (4) in accordance with claim 15, characterized by having sections made of steel.

27.(NEW) Tether system for tension leg platforms (4) in accordance with claim 15, characterized by having sections made of composite materials.

REMARKS

The present Preliminary Amendment is submitted to cancel original claims 1-12, add new claims 13-27, and to remove multiple claim dependencies, thereby placing such claims in condition for examination and reducing the required PTO filing fee.

Also, the specification and abstract have been revised in view of the IPER, and to add necessary headings. A substitute specification and abstract has been prepared. No new matter has been added. Also enclosed is a "a marked-up" copy of the original specification and abstract to show the changes that have been incorporated into the substitute specification and abstract. The enclosed copy is entitled *"Version with Markings to Show Changes Made."*

Finally, a proposed drawing correction to Fig. 1 is attached to add reference numerals that were described in the specification but not shown in the drawings.

Respectfully submitted,

Graham PERRET et al.

By ______________________
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December 19, 2001

COVER SHEET

FOR SUBSTITUTE SPECIFICATION

Graham PERRET et al.
Serial No. NEW
Filing Date: December 19, 2001

Attorney Docket No. 2001-1855A

10/018361
JC13 Rec'd PCT/PTO 19 DEC 2001

TITLE:

DEEP WATER TLP TETHER SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to the art of offshore structures and, more particularly, to tension leg platforms (TLP) for exploitation of deep sea hydrocarbon reserves.

Mooring elements, or tethers on tension leg platforms are anchored to the seabed. They usually consist of steel pipes and are kept in tension by the buoyancy of the platform.

With the gradual depletion of onshore and shallow sub sea subterranean hydrocarbon reservoirs, the search for additional petroleum reserves is being extended into deeper and deeper waters. As such deeper reservoirs are discovered, increasingly complex and sophisticated production systems are being developed. It is projected that soon, offshore exploration and production facilities will be required for probing depths of 1500m or more.

One way of reaching these depths is by using Tension Leg Patforms. A TLP comprises a semi-submersible-type floating platform anchored to foundations on the sea bed through members or mooring lines called tension legs or tethers. The tension legs are maintained in tension at all times by ensuring that the buoyancy of the TLP exceeds its operating weight under all environmental conditions. The TLP is compliantly restrained by this mooring system against lateral offset allowing limited surge, sway and yaw. Motions in the vertical direction of heave, pitch and roll are stiffly restrained by the tension legs.

External flotation systems can be attached to the legs but their long-term reliability is questionable. Furthermore, added buoyancy of this type causes an increase in the hydrodynamic forces on the leg structure.

TLPs' based on today's technology are considered competitive down to 1,000-1,500m. Beyond this depth, the tether system becomes increasingly heavy, requiring an increased platform size to carry the tether weight. This results in a larger platform, which has a significant impact on the overall cost.

For a TLP at 3,000m, a conventional tether system (one thickness, one diameter) represent a weight almost equal the payload. In previous designs, it has been proposed to reduce the wall thickness at the top to reduce the weight penalty.
A solution to avoid these disadvantages related to the TLP, is to modify the tether system to reduce the need for increased hull size. The industry has devoted a considerable effort to develop tether systems based on various designs. Filling tether pipes with low-density material, pressurising the interior to increase the hydrostatic capacity and replacing the steel tether pipes by composites are examples of these efforts.

Another solution can be found in NO 1997 3044, showing a design used for depths down to 700 m, built by pipe sections with a diameter between 0,5 to 1,2 m. The overall buoyancy of the tension leg is meant to be more or less neutral. This is achieved by adding an additional floating body at the top of the pipe.

NO 1997 3045 shows a welding connection on a tension leg. The publication shows two pipes of different diameter and wall thickness' welded together.

GB 2 081 659 A shows a floating platform mooring system for use in exploiting sub sea oil shoals that consists of a platform structure and an array of vertical tubular anchoring lines connected to the upright of the platform structure and to anchoring blocks on the sea bed. The patent shows anchoring lines consisting of a steel tube having resistance to yield stresses and having upper and lower sections. The upper section is a steel rod with a flexural stiffness which decreases from its point of connection to the upright. The lower section of the

anchoring line has a hollow configuration and is fixed to an anchoring block in order to achieve an optimum exploitation of the structural material.

However, the patent does not address the problems relating to the weight and pressure resistance of deep sea tension legs.

SUMMARY OF THE INVENTION

The object of the present invention is to overcome the above-mentioned deficiencies and to design tethers for TLP's that reduces the necessary added payload on the platform due to the tether weight. This object is achieved by a TLP as defined in the appending claims.

The invention relates to a tether system for TLP's, with tethers having upper and lower pipe sections, the tethers having a reduction of the diameter towards the seabed.

The invention is a concept for modifying today's technology for use in ultra deep waters. By introducing reductions in the tether diameter, the lower sections of the tether towards the sea bed will normally be negatively buoyant because of the considerable wall thickness necessary to withstand the hydrostatic pressure. The upper sections can more easily be made buoyant, as the hydrostatic pressure is less at the top. This will help to balance the overall weight of the upper and lower sections.

The tether pipes are dimensioned to carry the tension from a platform consisting of a nominal pre-tension plus the tension variation by functional and environmental loads. The pipes are kept empty, to reduce the weight/increase buoyancy. The pipes must not only be designed to withstand the loads applied by the platform, but also has to resist the hydrostatic pressure from the surrounding sea. This becomes more prominent as the depth/hydrostatic pressure increases. At great depths (in the order of 1,000m) the pipes can no longer be designed to have a neutral buoyancy (a diameter to thickness ratio of about 30). In order to

withstand the pressure, the diameter to thickness ratio has to be reduced, which results in added load on the platform.

The thickness of each section is sized according to capacity. It should also be considered that the tether vertical stiffness is critical for performance, and it is therefore favourable to maintain a fairly equal stiffness/length of each section.

The reduction of overall diameter will typically be made in steps, with intersections between the steps. The number of steps will depend on the length of the tether/depth of which it is to be used etc.
In-between each diameter, a transition piece carries the load. This is a well-proven detail from previous TLP applications.
The tethers may have a gradual transition between the upper and lower sections instead of the above described steps, but such tethers are less likely to be used as such tethers probably will require a more complex manufacturing process.

With near neutral tethers, the reduction of the hull weight is in the order of 30 percent as compared the hull weight when tethers according to prior art are used. This is due to the decrease of added payload when tethers of the invention are used.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be explained in more detail, with reference to the drawings in which

Figure 1 shows a tension leg platform with tethers according to the present invention;
Figure A1 shows the tension distribution of the two concepts;
Figure 2 shows a tether string according to the invention;
Figure A2 shows a schematic representation of tether pipe utilization.
Figure 3 shows a cross section of a diameter transition section; and

Figure 4 shows an optimisation chart where a tethers outer diameter and the wall thickness are plotted to show how buoyancy, stiffness and hydrostatic capacity varies.

DETAILED DESCRIPTION OF THE INVENTION

The following gives an embodiment by way of the following non-limiting example.

A tension leg platform (4) with one step and two tethers (6) having two diameters holding the platform is shown on Fig 1. A transition piece (3) between the diameters is shown on Fig 3 in detail. An upper part of a tether (1) may then have a diameter of 142 mm and a wall thickness of 24.5 mm, whereas the lower part (2) has an outer diameter of 76 mm and a wall thickness of 42 mm. The tethers are anchored to foundations (5).

A tether with two steps is shown on Fig 2.

The figure shows three tubular sections interconnected with two transition pieces (3). The three tubular sections have a reduction of the diameter towards the sea bed.

Figure A2 is a schematic representation of tether part utilization.

Samples of further variations in loads, dimensions and configurations are illustrated in Table 1. The embodiment suggests a wellhead platform in West African environment. The deck weight includes the facilities, the structural steel and the operational loads, including the riser tensions. The riser tensions are increased with water depth. The hull and displacement are increased to carry the deck load and the tether pretension.

The thick tether system represents the conventional one thickness tether, which has to have a large thickness to diameter ratio, to withstand the hydrostatic pressure at the bottom. The stepped tether system represents the invention, which allows for reduction of the displacement and of the hull weight.

Table 1 West Africa TLP Application

WATER DEPTH	(m)	1000m	1500m		2000m		3000m		
TETHER SYSTEM	**(-)**	**THICK**	**THICK**	**STEPPED**	**THICK**	**STEPPED**	**THICK**	**STEPPED**	**MAX. STEP**
DECK WEIGHT	(t)	4,800	5,000	5,000	5,300	5,300	5,900	5,900	5,900
RISER TENSION	(t)	2,800	4,200	4,200	5,600	5,600	8,400	8,400	8,400
HULL & BALLAST	(t)	5,300	6,000	5,800	7,100	6,400	10,100	8,200	7,700
TETHER PRETENSION	(t)	2,400	3,300	2,600	5,500	3,000	13,000	6,200	4,500
DISPLACEMENT		**15,300**	**18,500**	**17,600**	**23,500**	**20,300**	**37,400**	**28,700**	**26,500**
TETHERS									
NO. OF DIAMETERS		1	1	2	1	2	1	5	10
DIAMETER (top/bott.)	Inch	26	30	46/24	32	52/28	34	56/30	56/30
DIAMETER (top/bott.)	mm	66	76	117/61	81	132/71	86	142/76	142/76
THICKNESS (top/bott)	mm	22.2	28.5	38.5/23	35.5	34.5/31	47.5	24.5/42	24.5/42
MAX. LOAD – TOP	(kN)	7,200	8,900	8,100	12,400	8,000	24,000	14,700	12,600
WEIGHT in WATER	(t)	0	70	-10	300	20	1,100	300	70

The above described embodiments use steel as the construction material, but the invention is also meant to cover other materials such as composites.

Abstract

The invention proposes to increase the diameter of the top sections (2) of the tethers on tension leg platforms (TLP) (4) to the make top sections (1) positively buoyant. This buoyancy can be designed to compensate for the weight of the lower sections (2) to make the total buoyancy of the tether closer to neutral. The selection process for each section is driven by requirements for buoyancy, stiffness and external pressure resistance.

14. DEC. 2001 15:06 BRYN & AARFLOT AS +47 22003131 NO. 3527 P. 17

Amended specification and

10/018361
JC13 Rec'd PCT/PTO 19 DEC 2001

TITLE: all caps

Deep water TLP Tether System

BACKGROUND OF THE INVENTION

This invention relates to the art of offshore structures and, more particularly, to tension leg platforms (TLP) for exploitation of deep sea hydrocarbon reserves.

Mooring elements, or tethers on tension leg platforms are anchored to the sea-bed. They usually consist of steel pipes and are kept in tension by the buoyancy of the platform.

With the gradual depletion of onshore and shallow sub sea subterranean hydrocarbon reservoirs, the search for additional petroleum reserves is being extended into deeper and deeper waters. As such deeper reservoirs are discovered, increasingly complex and sophisticated production systems are being developed. It is projected that soon, offshore exploration and production facilities will be required for probing depths of 1500m or more.

One way of reaching these depths is by using Tension Leg Patforms. A TLP comprises a semi-submersible-type floating platform anchored to foundations on the sea bed through members or mooring lines called tension legs or tethers. The tension legs are maintained in tension at all times by ensuring that the buoyancy of the TLP exceeds its operating weight under all environmental conditions. The TLP is compliantly restrained by this mooring system against lateral offset allowing limited surge, sway and yaw. Motions in the vertical direction of heave, pitch and roll are stiffly restrained by the tension legs.

External flotation systems can be attached to the legs but their long-term reliability is questionable. Furthermore, added buoyancy of this type causes an increase in the hydrodynamic forces on the leg structure.

TLPs' based on today's technology are considered competitive down to 1,000-1,500m. Beyond this depth, the tether system becomes increasingly heavy, requiring an increased platform size to carry the tether weight. This results in a larger platform, which has a significant impact on the overall cost.

For a TLP at 3,000m, a conventional tether system (one thickness, one diameter) represent a weight almost equal the payload. In previous designs, it has been proposed to reduce the wall thickness at the top to reduce the weight penalty. A solution to avoid these disadvantages related to the TLP, is to modify the tether system to reduce the need for increased hull size. The industry has devoted a considerable effort to develop tether systems based on various designs. Filling tether pipes with low-density material, pressurising the interior to increase the hydrostatic capacity and replacing the steel tether pipes by composites are examples of these efforts.

Another solution can be found in NO 1997 3044, showing a design used for depths down to 700 m, built by pipe sections with a diameter between 0,5 to 1,2 m. The overall buoyancy of the tension leg is meant to be more or less neutral. This is achieved by adding an additional floating body at the top of the pipe.

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load on the platform due to the tether weight. This object is achieved by a TLP as defined in the appending claims.

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The tether pipes are dimensioned to carry the tension from a platform consisting of a nominal pre-tension plus the tension variation by functional and environmental loads. The pipes are kept empty, to reduce the weight/increase buoyancy. The pipes must not only be designed to withstand the loads applied by the platform, but also has to resist the hydrostatic pressure from the surrounding sea. This becomes more prominent as the depth/hydrostatic pressure increases. At great depths (in the order of 1,000m) the pipes can no longer be designed to have a neutral buoyancy (a diameter to thickness ratio of about 30). In order to withstand the pressure, the diameter to thickness ratio has to be reduced, which results in added load on the platform.

The thickness of each section is sized according to capacity. It should also be considered that the tether vertical stiffness is critical for performance, and it is therefore favourable to maintain a fairly equal stiffness/length of each section.

The reduction of overall diameter will typically be made in steps, with intersections between the steps. The number of steps will depend on the length of the tether/depth of which it is to be used etc.

In-between each diameter, a transition piece carries the load. This is a well-proven detail from previous TLP applications.

The tethers may have a gradual transition between the upper and lower sections instead of the above described steps, but such tethers are less likely to be used as such tethers probably will require a more complex manufacturing process.

With near neutral tethers, the reduction of the hull weight is in the order of 30 percent as compared the hull weight when tethers according to prior art are used. This is due to the decrease of added payload when tethers of the invention are used.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be explained in more detail, with reference to the drawings in which :

Figure 1 shows a tension leg platform with tethers according to the present invention;
Figure A1 shows the tension distribution of the two concepts;
Figure 2 shows a tether string according to the invention;
Figure A2 shows a schematic representation of tether pipe utilization.
Figure 3 shows a cross section of a diameter transition section; and
Figure 4 shows an optimisation chart where a tethers outer diameter and the wall thickness are plotted to show how buoyancy, stiffness and hydrostatic capacity varies.

DETAILED DESCRIPTION OF THE ~~DRAWINGS~~ INVENTION

The following gives an embodiment by way of the following non-limiting example.

A tension leg platform [TLP] (4) with one step and two tethers (6) having two diameters holding the platform is shown on Fig 1. A transition piece (3) between the diameters is shown on Fig 3 in detail. An upper part of a tether (1) may then have a diameter of 142 mm and a wall thickness of 24.5 mm, whereas the lower part (2) has an outer diameter of 76 mm and a wall thickness of 42 mm. The tethers are anchored to foundations (5).

A tether with two steps is shown on Fig 2.

The figure shows three tubular sections interconnected with two transition pieces (3). The three tubular sections have a reduction of the diameter towards the sea bed.

Figure A2 is a schematic representation of tether part utilization.

Samples of further variations in loads, dimensions and configurations are illustrated in Table 1. The embodiment suggests a wellhead platform in West African environment. The deck weight includes the facilities, the structural steel and the operational loads, including the riser tensions. The riser tensions are increased with water depth. The hull and displacement are increased to carry the deck load and the tether pretension.

The thick tether system represents the conventional one thickness tether, which has to have a large thickness to diameter ratio, to withstand the hydrostatic pressure at the bottom. The stepped tether system represents the invention, which allows for reduction of the tether pretension. This allows for reduction of the displacement and of the hull weight.

Table 1 West Africa TLP Application

WATER DEPTH	(m)	1000m	1500m		2000m		3000m		
TETHER SYSTEM	(-)	THICK	THICK	STEPPED	THICK	STEPPED	THICK	STEPPED	MAX. STEP
DECK WEIGHT	(t)	4,800	5,000	5,000	5,300	5,300	5,900	5,900	5,900
RISER TENSION	(t)	2,800	4,200	4,200	5,600	5,600	8,400	8,400	8,400
HULL & BALLAST	(t)	5,300	6,000	5,800	7,100	6,400	10,100	8,200	7,700
TETHER PRETENSION	(t)	2.400	3,300	2,600	5,500	3,000	13,000	6,200	4,500
DISPLACEMENT		**15,300**	**18,500**	**17,600**	**23,500**	**20,300**	**37,400**	**28,700**	**26,500**

TETHERS									
NO. OF DIAMETERS		1	1	2	1	2	1	5	10
DIAMETER (top/bott.)	inch	26	30	46/24	32	52/28	34	56/30	56/30
DIAMETER (top/bott.)	mm	66	76	117/61	81	132/71	86	142/76	142/76
THICKNESS (top/bott)	mm	22.2	28.5	38.5/23	35.5	34.5/31	47.5	24.5/42	24.5/42
MAX. LOAD – TOP	(kN)	7,200	8,900	8,100	12,400	8,000	24,000	14,700	12,600
WEIGHT in WATER	(t)	0	70	-10	300	20	1,100	300	70

The above described embodiments use steel as the construction material, but the invention is also meant to cover other materials such as composites.

10/018361
JC13 Rec'd PCT/PTO 19 DEC 2001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of	:	
Graham PERRET et al.	:	Docket No. 2001_1855A
Serial No. NEW	:	**Attn: APPLICATION BRANCH**
Filed December 19, 2001	:	
DEEP WATER TLP TETHER SYSTEM	:	

LETTER RE PROPOSED DRAWING AMENDMENTS

Assistant Commissioner for Patents,
Washington, D.C.

Sir:

Enclosed herewith is a photocopy of Fig. 1 highlighted in yellow to indicate proposed drawing amendments thereto.

The Examiner is requested to approve such proposed drawing amendments, and then formal drawings incorporating such amendments will be filed.

Respectfully submitted,

Graham PERRET et al.

By Michael Huppert
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December 19, 2001

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Amended Sheet 10/018361

Proposed 1/4 Drawing Correction

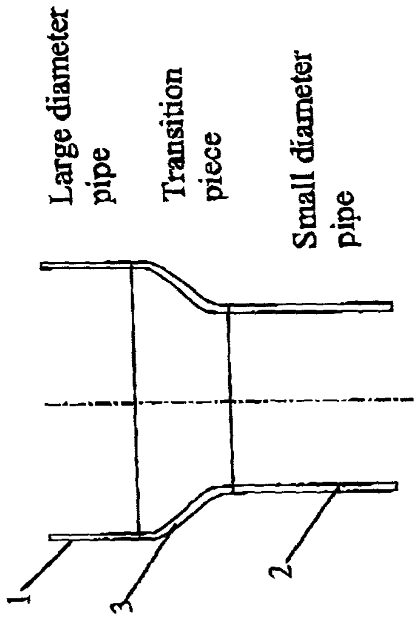

Figure 3: Diameter transition

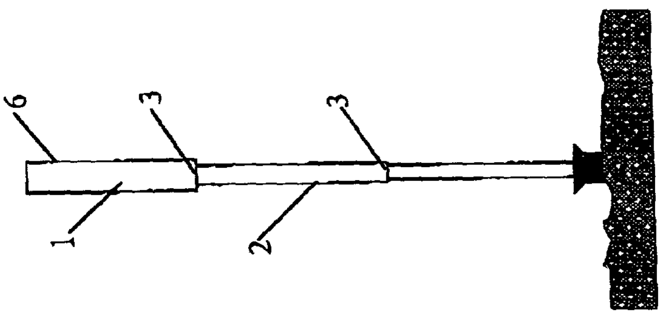

Figure 2: Tether string

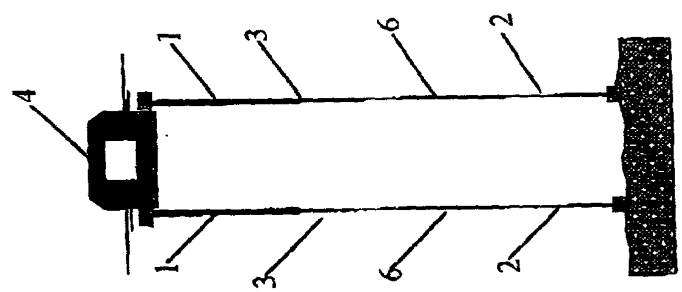

Figure 1: TLP with tethers

Deep water TLP Tether System

This invention relates to the art of offshore structures and, more particularly, to tension leg platforms (TLP) for exploitation of deep sea hydrocarbon reserves .

Mooring elements, or tethers on tension leg platforms are anchored to the sea-bed. They usually consist of steel pipes and are kept in tension by the buoyancy of the platform.

With the gradual depletion of onshore and shallow subsea subterranean hydrocarbon reservoirs, the search for additional petroleum reserves is being extended into deeper and deeper waters. As such deeper reservoirs are discovered, increasingly complex and sophisticated production systems are being developed. It is projected that soon, offshore exploration and production facilities will be required for probing depths of 1500m or more.

One way of reaching these depths is by using Tension Leg Patforms. A TLP comprises a semi-submersible-type floating platform anchored to foundations on the sea bed through members or mooring lines called tension legs or tethers. The tension legs are maintained in tension at all times by ensuring that the buoyancy of the TLP exceeds its operating weight under all environmental conditions. The TLP is compliantly restrained by this mooring system against lateral offset allowing limited surge, sway and yaw. Motions in the vertical direction of heave, pitch and roll are stiffly restrained by the tension legs.

External flotation systems can be attached to the legs but their long-term reliability is questionable. Furthermore, added buoyancy of this type causes an increase in the hydrodynamic forces on the leg structure.

TLPs' based on today's technology are considered competitive down to 1,000-1,500m. Beyond this depth, the tether system becomes increasingly heavy, requiring an increased platform size to carry the tether weight. This results in a larger platform, which has a significant impact on the overall cost.

For a TLP at 3,000m, a conventional tether system (one thickness, one diameter) represent a weight almost equal the payload. In previous designs, it has been proposed to reduce the wall thickness at the top to reduce the weight penalty. A solution to avoid these disadvantages related to the TLP, is to modify the tether system to reduce the need for increased hull size. The industry has devoted a considerable effort to develop tether systems based on various designs. Filling tether pipes with low density material, pressurising the interior to increase the hydrostatic capacity and replacing the steel tether pipes by composites are examples of these efforts.

Another solution can be found in NO 1997 3044, showing a design used for depths down to 700 m, built by pipe sections with a diameter between 0,5 to 1,2 m. The overall buoyancy of the tension leg is meant to be more or less neutral. This is achieved by adding an additional floating body at the top of the pipe.

NO 1997 3045 shows a welding connection on a tension leg. The publication shows two pipes of different diameter and wall thickness' welded together.

The object of the present invention is to overcome the above mentioned deficiencies and to design tethers for TLP's that reduces the necessary added payload on the platform due to the tether weight. This object is achieved by a TLP as defined in the appending claims.

The invention relates to a tether system for TLP's, with tethers having upper and lower pipe sections, the tethers having a reduction of the diameter towards the seabed.
The invention is a concept for modifying today's technology for use in ultra deep waters. By introducing reductions in the tether diameter, the lower sections of the tether towards the sea bed will normally be negatively buoyant because of the considerable wall thickness necessary to withstand the hydrostatic pressure. The upper sections can more easily be made buoyant as the hydrostatic pressure is

less at the top. This will help to balance the overall weight of the upper and lower sections.

The tether pipes are dimensioned to carry the tension from a platform consisting of a nominal pre-tension plus the tension variation by functional and environmental loads. The pipes are kept empty, to reduce the weight/increase buoyancy. The pipes must not only be designed to withstand the loads applied by the platform, but also has to resist the hydrostatic pressure from the surrounding sea. This becomes more prominent as the depth/hydrostatic pressure increases. At great depths (in the order of 1,000m) the pipes can no longer be designed to have a neutral buoyancy (a diameter to thickness ratio of about 30). In order to withstand the pressure, the diameter to thickness ratio has to be reduced, which results in added load on the platform.

The thickness of each section is sized according to capacity. It should also be considered that the tether vertical stiffness is critical for performance, and it is therefore favourable to maintain a fairly equal stiffness/length of each section.

The reduction of overall diameter will typically be made in steps, with intersections between the steps. The number of steps will depend on the length of the tether/depth of which it is to be used etc.
In-between each diameter, a transition piece carries the load. This is a well proven detail from previous TLP applications.

The tethers may have a gradual transition between the upper and lower sections instead of the above described steps, but such tethers are less likely to be used as such tethers probably will require a more complex manufacturing process.

With near neutral tethers, the reduction of the hull weight is in the order of 30 percent as compared the hull weight when tethers according to prior art are used. This is due to the decrease of added payload when tethers of the invention are used.

The invention will now be explained in more detail, with reference to the drawings in which

Figure 1 shows a tension leg platform with tethers according to the present invention;
Figure A1 shows the tension distribution of the two concepts;
Figure 2 shows a tether string according to the invention;
Figure 3 shows a cross section of a diameter transition section; and
Figure 4 shows an optimisation chart where a tethers outer diameter and the wall thickness are plotted to show how buoyancy, stiffness and hydrostatic capacity varies.

The following gives an embodiment by way of the following non-limiting example.

A TLP (4) with one step and two tethers (6) having two diameters holding the platform is shown on Fig 1. A transition piece (3) between the diameters is shown on Fig 3 in detail. An upper part of a tether (1) may then have a diameter of 142 mm and a wall thickness of 24.5 mm, whereas the lower part (2) has an outer diameter of 76 mm and a wall thickness of 42 mm. The tethers are anchored to foundations (5).

A tether with two steps is shown on Fig 2.

Samples of further variations in loads, dimensions and configurations are illustrated in Table 1. The embodiments suggests a wellhead platform in West African environment. The deck weight includes the facilities, the structural steel and the operational loads, including the riser tensions. The riser tensions are increased with water depth. The hull and displacement are increased to carry the deck load and the tether pretension.

The thick tether system represents the conventional one thickness tether, which has to have a large thickness to diameter ratio, to withstand the hydrostatic pressure at the bottom. The stepped tether system represents the invention, which allows for reduction of the tether pretension. This allows for reduction of the displacement and of the hull weight.

Table 1 West Africa TLP Application

WATER DEPTH	(m)	1000m	1500m		2000m		3000m		
TETHER SYSTEM	(-)	THICK	THICK	STEPPED	THICK	STEPPED	THICK	STEPPED	MAX. STEP
DECK WEIGHT	(t)	4,800	5,000	5,000	5,300	5,300	5,900	5,900	5,900
RISER TENSION	(t)	2,800	4,200	4,200	5,600	5,600	8,400	8,400	8,400
HULL & BALLAST	(t)	5,300	6,000	5,800	7,100	6,400	10,100	8,200	7,700
TETHER PRETENSION	(t)	2,400	3,300	2,600	5,500	3,000	13,000	6,200	4,500
DISPLACEMENT		15,300	18,500	17,600	23,500	20,300	37,400	28,700	26,500
TETHERS									
NO. OF DIAMETERS		1	1	2	1	2	1	5	10
DIAMETER (top/bott.)	Inch	26	30	46/24	32	52/28	34	56/30	56/30
DIAMETER (top/bott.)	mm	66	76	117/61	81	132/71	86	142/76	142/76
THICKNESS (top/bott)	mm	22.2	28.5	38.5/23	35.5	34.5/31	47.5	24.5/42	24.5/42
MAX. LOAD – TOP	(kN)	7,200	8,900	8,100	12,400	8,000	24.000	14,700	12,600
WEIGHT in WATER	(t)	0	70	-10	300	20	1,100	300	70

The above described embodiments use steel as the construction material, but the invention is also meant to cover other materials such as composites.

Claims:

1. Tether system for tension leg platforms (4), with tethers (6) having upper and lower pipe sections (1, 2), characterised by the tethers (6) having a stepped reduction of the diameter towards the seabed such that the upper section(s) (1) have positive buoyancy, and such that the upper section(s) (1) compensate for the weight in water of the lower section(s) (2).

2. Tether system for tension leg platforms (4) according to claim 1, characterised by tethers (6) with an increasing pressure resistance as the depth towards the sea-bed increases.

3. Tether system for tension leg platforms, characterised by tethers (6) having pipes of different diameter, with a substantially continuous reduction towards the seabed, and an increased pressure resistance towards the sea-bed.

4. Tether system for tension leg platforms (4) in accordance with claim 1 or 3, characterised by the tether system having a weight in water close to neutral.

5. Tether system for tension leg platforms (4) according to claim 1, characterised by tethers having pipes with at least two stepped reductions of the diameter towards the seabed.

6. Tether system for tension leg platforms (4) according to claim 1, characterised by tethers having pipes with at least two stepped increases of the wall thickness towards the seabed.

7. Tether system for tension leg platforms (4) in accordance with claim 1 or 3, characterised by having upper sections (1) with reduced wall thickness such that the total cross sectional area of the pipe wall is maintained approximately constant over the height.

8. Tether system for tension leg platforms (4) in accordance with claim 1 or 3, characterised by having sections made of steel.

9. Tether system for tension leg platforms (4) in accordance with claim 1 or 3, characterised by having sections made of composite materials.

10. Tethers (6) for deep sea use, characterised by having pipes with a stepped reduction of the diameter towards the seabed.

11. Tethers (6) for deep sea use according to claim 10, characterised by using the tethers on tension leg platforms

12. Tethers (6) for deep sea use, characterised by having decreasing buoyancy towards the seabed

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(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

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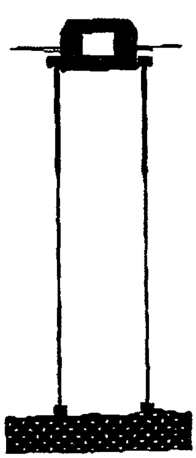
Published:
— *With international search report.*
— *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: DEEP WATER TLP TETHER SYSTEM

(57) **Abstract:** The invention proposes to increase the diameter of the top sections (2) of the tethers on tension leg platforms (TLP) (4) to the make top sections (1) positively buoyant. This buoyancy can be designed to compensate for the weight of the lower sections (2) to make the total buoyancy of the tether closer to neutral. The selection process for each section is driven by requirements for buoyancy, stiffness and external pressure resistance.



TLP with tethers

WO 00/78601 A1

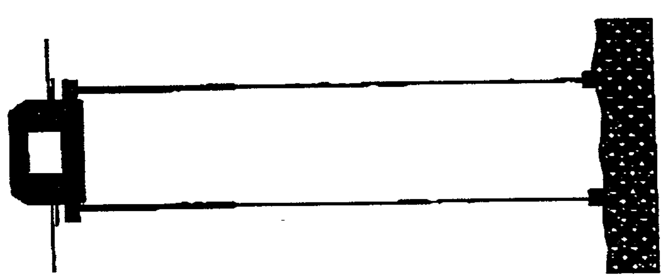


Figure 1:
TLP with tethers

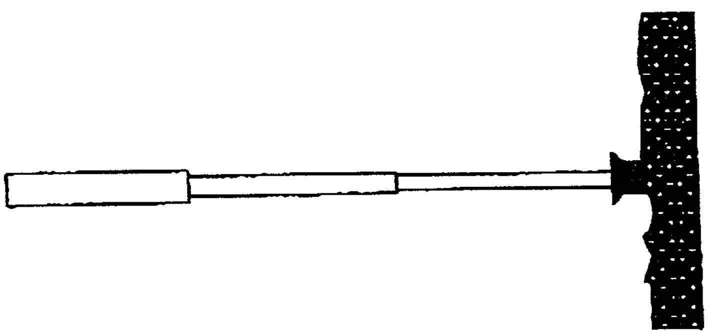


Figure 2:
Tether string

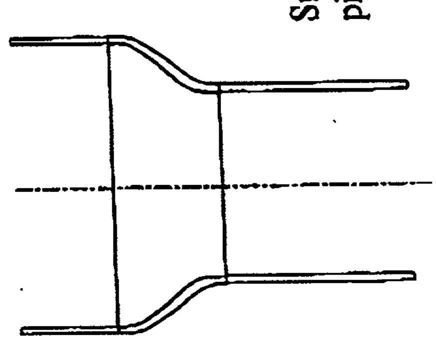


Figure 3:
Diameter transition

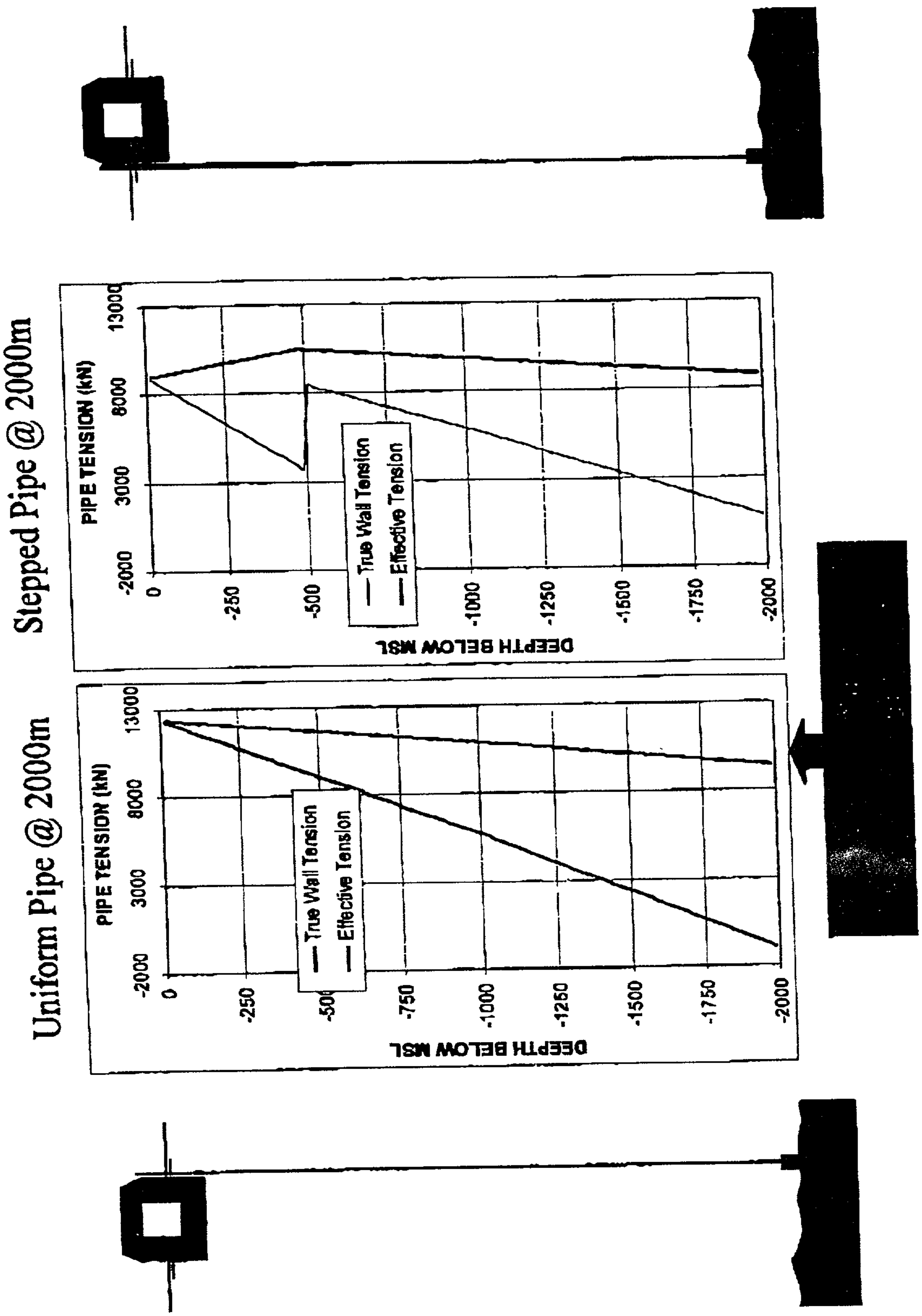


Figure A1 Tether Pipe Tension

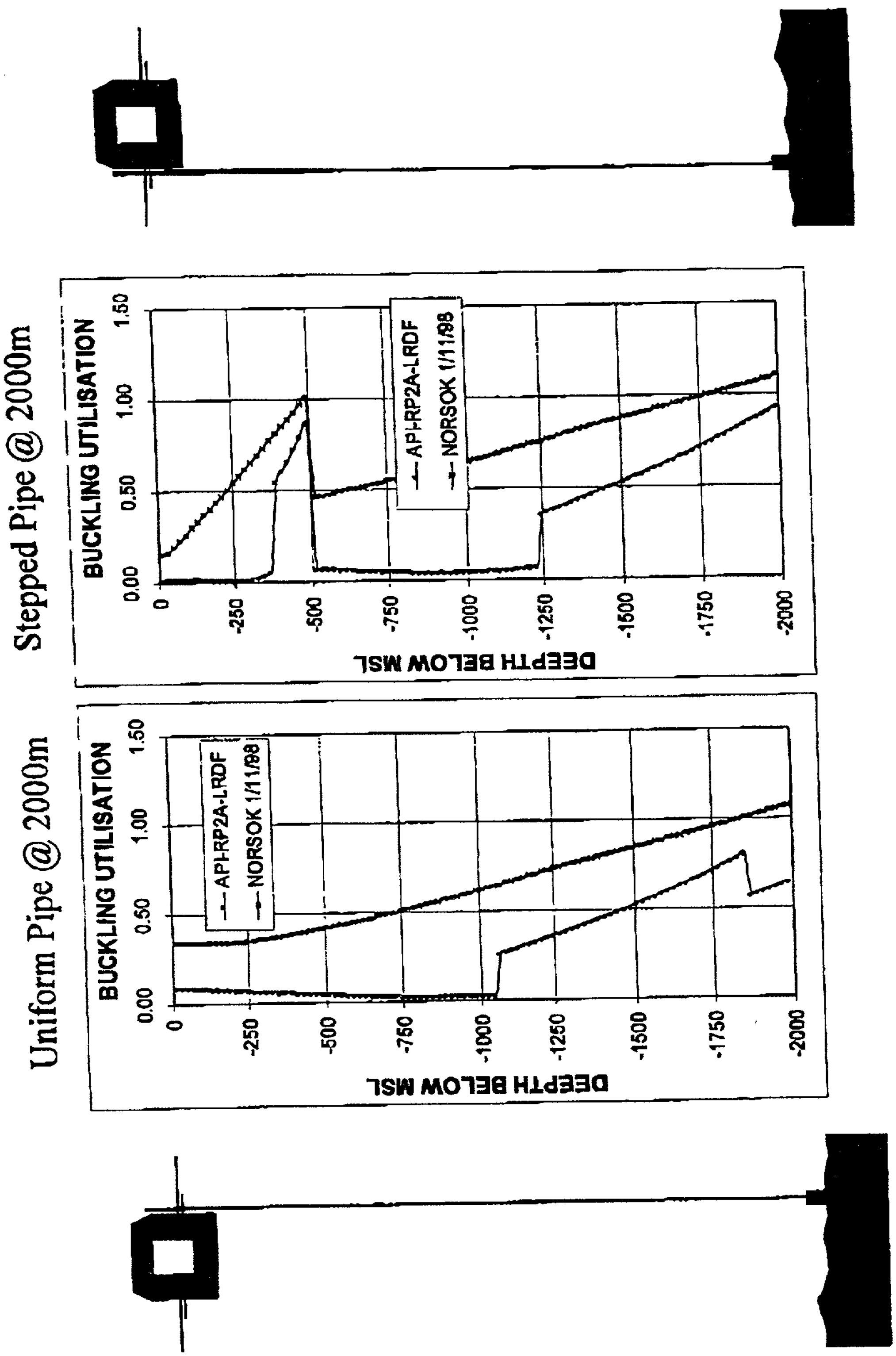


Figure A2 Tether Pipe Utilization

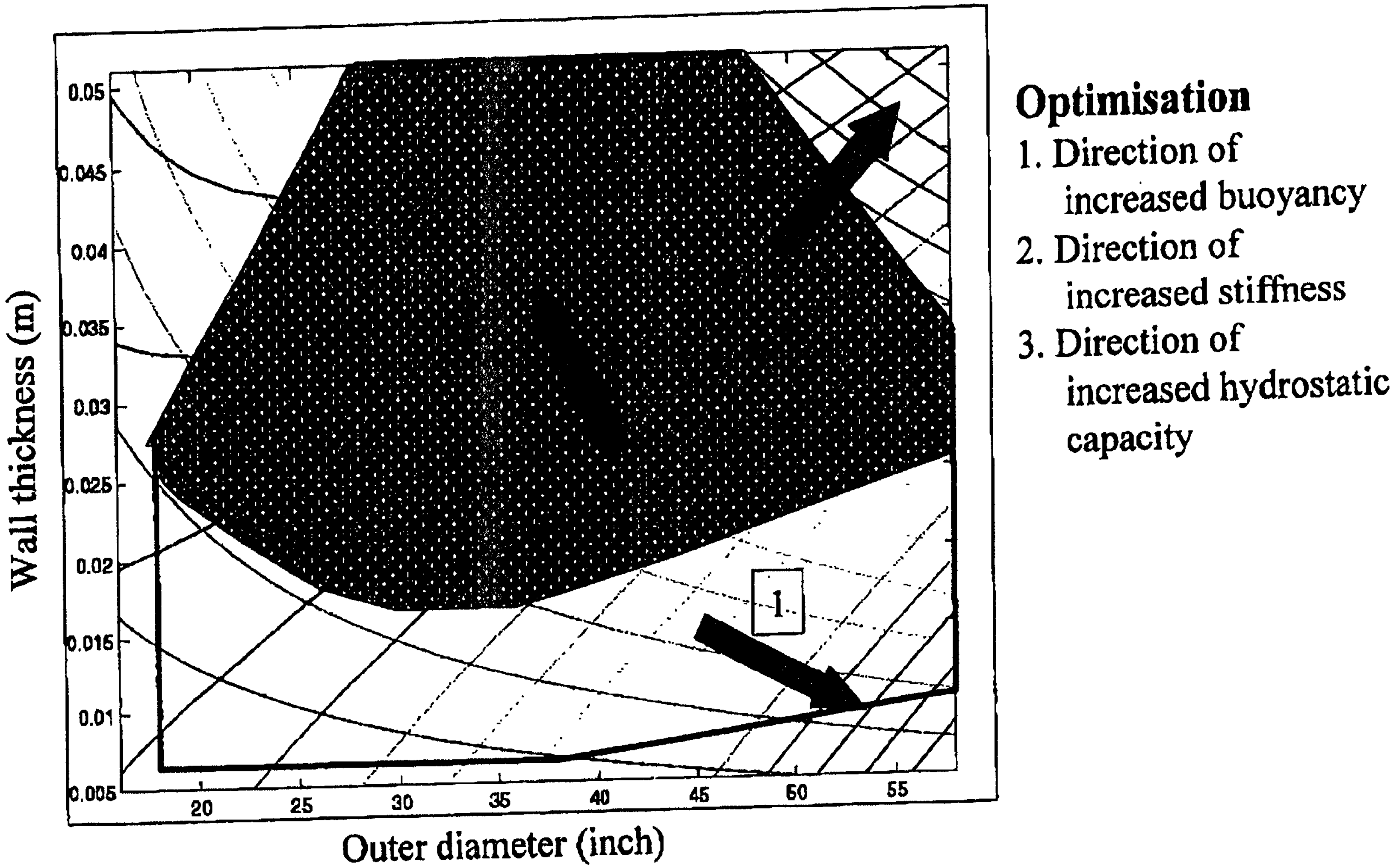


Figure 4: Optimisation chart

Rev. 3-21-01 Effective March 1998

DECLARATION AND POWER OF ATTORNEY FOR U.S. PATENT APPLICATION

() Original () Supplemental () Substitute (X) PCT () DESIGN

As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that I verily believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Title: DEEP WATER TLP TETHER SYSTEM

of which is described and claimed in:
() the attached specification, or
() the specification in application Serial No. ____________________, filed ________________, and with amendments through ________________, or
(X) the specification in International Application No. PCT/NO00/00215, filed June 22, 2000, and as amended on _(if applicable).

I hereby state that I have reviewed and understand the content of the above-identified specification, including the claims, as amended by any amendment(s) referred to above.

I acknowledge my duty to disclose to the Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I hereby claim priority benefits under Title 35, United States Code, §119 (and §172 if this application is for a Design) of any application(s) for patent or inventor's certificate listed below and have also identified below any application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

COUNTRY	APPLICATION NO.	DATE OF FILING	PRIORITY CLAIMED
Norway	1999 3116	June 23, 1999	YES

I hereby claim the benefit under Title 35, United States Code §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose information material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

APPLICATION SERIAL NO.	U.S. FILING DATE	STATUS: PATENTED, PENDING, ABANDONED

And I hereby appoint Michael R. Davis, Reg. No. 25,134; Matthew M. Jacob, Reg. No. 25,154; Warren M. Cheek, Jr., Reg. No. 33,367; Nils Pedersen, Reg. No. 33,145; Charles R. Watts, Reg. No. 33,142; and Michael S. Huppert, Reg. No. 40,268, who together constitute the firm of WENDEROTH, LIND & PONACK, L.L.P., as well as any other attorneys and agents associated with Customer No. 000513, to prosecute this application and to transact all business in the U.S. Patent and Trademark Office connected therewith.

I hereby authorize the U.S. attorneys and agents named herein to accept and follow instructions from Bryn & Aarflot AS as to any action to be taken in the U.S. Patent and Trademark Office regarding this application without direct communication between the U.S. attorneys and myself. In the event of a change in the persons from whom instructions may be taken, the U.S. attorneys named herein will be so notified by me.

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1-00

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2-00

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3-00

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Post Office Address	ADDRESS	CITY	STATE OR COUNTRY	ZIP CODE

Full Name of Sixth Inventor	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
Residence & Citizenship	CITY	STATE OR COUNTRY	COUNTRY OF CITIZENSHIP	
Post Office Address	ADDRESS	CITY	STATE OR COUNTRY	ZIP CODE

I further declare that all statements made herein of my own knowledge are true, and that all statements on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

1st Inventor ______________________ Date 1/2/2002
Graham PERRET

2nd Inventor ______________________ Date ____________
Henrik HANNUS

3rd Inventor ______________________ Date ____________
Kjetil ECKHOFF

4th Inventor ______________________ Date ____________

5th Inventor ______________________ Date ____________

6th Inventor ______________________ Date ____________

The above application may be more particularly identified as follows:

U.S. Application Serial No. ____________ Filing Date ____________

Applicant Reference Number 105341/JH/JE Atty Docket No. 2001_1855A

Title of Invention DEEP WATER TLP TETHER SYSTEM

I further declare that all statements made herein of my own knowledge are true, and that all statements on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

1st Inventor ______________________ Date ____________
Graham PERRET
2nd Inventor ______________________ Date ____________
Henrik HANNUS
3rd Inventor Henrik Hannus Date 1/24/2002
Kjetil ECKHOFF
4th Inventor ______________________ Date ____________

5th Inventor ______________________ Date ____________

6th Inventor ______________________ Date ____________

The above application may be more particularly identified as follows:

U.S. Application Serial No. ______________ Filing Date ______________

Applicant Reference Number 105341/JH/JB Atty Docket No. 2001_1855A

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1st Inventor ______________________ Date ____________
Graham PERRET
2nd Inventor ______________________ Date ____________
Henrik HANNUS
3rd Inventor Kjetil Eckhoff Date 20/1-2002
Kjetil ECKHOFF
4th Inventor ______________________ Date ____________

5th Inventor ______________________ Date ____________

6th Inventor ______________________ Date ____________

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